91602
new 82-10

ontario hydro
research division

EXECUTIVE SUMMARY

TRITIATED WASTE CONDITIONING PART III (b), (c) & (d) THE CONDITIONING AND LEACHING PERFORMANCE OF TRITIATED OIL, ELECTROLYZER FLUID AND METALLIC WASTE

J.P. Krasznai
Engineer
Chemical Research Department

The Darlington Tritium Removal Facility is expected to generate a variety of tritiated liquid and solid waste streams. Some of these wastes, because of their physical characteristics and high activity levels, must be conditioned prior to their placement into long term storage or final disposal to ensure that the tritium losses to the environment are acceptably small.

In the absence of any firm criteria for tritium releases to the environment from tritiated wastes, we have assumed in this work that:

(a) the waste package must retain its integrity for 150 years, and

(b) the daily tritium loss rate must not exceed 10^{-3} %.

Part III (a) of this report considered the conditioning requirements for aqueous waste and determined that these criteria cannot be met unless the waste is first immobilized to avoid dispersion of the waste and then packaged in a multi- walled, water-impermeable package such as high density polyethylene surrounded by a polyethylene or steel overpack.

The work described in the attached report considers the conditioning requirements for three other tritiated waste streams, namely vacuum pump oil, electrolyzer fluid (25% KOD) and tritiated metallic components. It is desirable from both operational and economic considerations to use a single solidification medium to treat all tritiated liquid waste streams. Aqueous tritiated waste and metallic components are compatible with both cement and water extendible polyester resin.

job	file	date	report no.
32-600-060	837.83	December 1, 1986	86-171-K

However, vacuum pump oils and electrolyzer fluid can only be incorporated into water extendible resin if they are used at very low waste to resin ratio and only if the electrolyzer fluid is diluted. These waste streams are, however, compatible with cement based formulations.

The tritium release rate from contaminated oils contained in high density polyethylene is dependent on the type of species and their concentration in the oil. If the major contaminant is tritiated water, the release rate through a 0.1 cm thick HDPE container exceeds the 10^{-3}% per day target value. This is a surprising observation in view of our earlier findings that a 0.1 cm thick HDPE container was quite adequate in retaining tritiated water. This effect is attributed to a significant absorption of the oil by the polyethylene container, which reduces its effective thickness. Immobilizing the oil is therefore required not only to avoid dispersion of the contents of the container should it be breached but also to minimize the absorption of the oil into the polyethylene.

In view of the fact that (a) the release rate of tritium from tritiated oils is dependent on the relative concentration of tritiated water in the oil and (b) the Darlington TRF is not yet operational and therefore real samples of waste oil are not available, it is difficult to recommend the most suitable waste handling strategy. Cement encapsulation of the oil in combination with an increase in container thickness to 0.25 cm will be adequate to meet the tritium release rate target regardless of the species carrying the tritium. The disadvantages of this process however are that the waste loading is less than 50% by volume and processing the waste requires high speed mixing which could result in volatile tritium species especially tritium gas to be released thereby reducing the benefits of waste conditioning. The use of other absorbents such as Sorbent C, a cellulose fiber material commonly used to soak up oil spills, will require that the tritiated water content of the oil be low (<20%) and that the container thickness be increased to 0.25 cm. The advantages of using such an absorbent system are twofold:

(1) Simple to implement since the tritiated oil can be drained from the vacuum pump directly into a polyethylene container of suitable thickness containing the absorbent.

(2) The waste loading capacity of the absorbent is comparatively high.

A small capacity vacuum distilling unit could be used to remove most of the tritiated water from the oil to make this waste processing system workable; however, some additional research would be required to determine the rate of production of tritiated water in the waste due to oxidation of the tritiated hydrocarbons and dissolved tritium gas during extended storage. Electrolyzer fluid (25% KOD solution) can be either immobilized in cement using a mixture of Portland cement and silica fume in the ratio of 95:5 or absorbed onto sawdust. The leaching performance of the resulting solidified waste form did not meet the specifications and as with other tritiated liquids the polyethylene container will function as the primary tritium barrier.

Depending on the material type and history of exposure, metallic waste incorporates a significant quantity (>25%) of the tritium in the oxide scale which is easily released during leaching and most probably also on standing in humid air. For copper, when this surface contamination is removed, the remaining bulk tritium is released at a rate which is much lower than the target release rate and no further conditioning is necessary. Stainless steel on the other hand releases tritium at a slow steady rate which exceeds 10^{-3}% per day. Encapsulating the components with a high water content solidification medium such as water extendible polyester resin will ensure that any tritium released from the metal will be diluted by isotopic exchange with water in the encapsulating agent before permeating through the polyethylene container. The tritium concentration gradient and hence tritium permeation across the container walls is reduced as a result of this dilution. The most practical approach for handling tritiated metals is to add the components to tritiated liquid wastes while the solidification agent is in the gel stage of curing.

It is clear from this and earlier work that the emphasis in the conditioning of tritiated wastes must be on waste packaging in order to meet the waste form integrity criteria. Based on this work it is recommended that the primary barrier against tritium loss should be high density polyethylene with a wall thickness that compensates for any reduction of effectiveness by virtue of attack of the polyethylene by tritiated organics in the waste. A container wall thickness of 1 cm should be adequate to meet the tritium release rate target of 10^{-3}% per day for all of the expected waste streams. This primary barrier however cannot be guaranteed to meet the 150 year package integrity criterion by itself. Consequently it is recommended that a secondary container or overpack be used to provide physical protection to the primary barrier during emplacement into extended storage or

disposal and significantly delay the access of groundwater to the primary barrier. For disposal conditions a stainless steel overpack is preferred to carbon steel due to its superior corrosion resistance. Under extended storage conditions which currently exist for waste at BNPD, polyethylene or epoxy lined carbon steel drums are considered adequate as overpacks for tritiated wastes.

91601
new 82-10

ontario hydro
research division

To: Dr.D. Mills
Director of Research

TRITIATED WASTE CONDITIONING PART III (b), (c) & (d)

J.P. Krasznai

The requirements for the conditioning of tritiated oils, electrolyzer fluid and non-processable metallic components expected to be generated by the Darlington Tritium Removal facility have been determined. The tritium release from waste oils is dependent on the tritium carrying species. Tritiated water in the oil gives rise to the highest release rates with tritiated hydrocarbons contributing negligibly to the overall release rates. The tritiated water release rate is a factor of 1000 greater when oil is present in the container. This is attributed to absorption of the oil into the walls of the polyethylene container which has the overall effect of reducing the container wall thickness. Electrolyzer solution can be immobilized either in cement or an absorbent such as sawdust but the primary barrier against tritium loss is the polyethylene container. Tritiated metallic components contain a significant quantity of surface tritium which is easily washed off. For copper components, once this surface contamination has been removed no further conditioning is required. Stainless steel components should be encapsulated in a high water content medium such as WEP resin or cement followed by containerization in high density polyethylene. For all tritiated waste streams the container functions as the primary tritium barrier because of its low water permeability.

1.0 INTRODUCTION

A program to determine conditioning and packaging requirements for tritiated waste/1/ expected to be generated at the Darlington Tritium Removal Facility is continuing. The conditioning

requirements and the performance under leaching conditions of both containerized and encapsulated solidified aqueous waste have been reported in references 2,3 and in Part III(a)/4/ of this report. These studies concluded that in order to achieve a daily tritium release rate of less than 10^{-3}% of the original activity, a water impermeable container such as high density polyethylene must be used as the primary barrier. In addition, to meet the requirement that tritium in a waste package be contained for at least 150 years (12 half lives), a multi-walled package is required whereby the innermost container functions as the primary barrier against tritium release from the waste form. The outer container is the barrier against groundwater ingress (under disposal conditions) and also provides structural strength to the package during emplacement in a waste disposal or extended storage facility.

These criteria have been adopted from those developed/5/ for countries with reprocessing facilities. They may be conservative criteria but easily achievable and consistent with the ALARA concept.

This report considers the conditioning requirements for three unique tritiated waste streams:

(1) Waste oil (75L/year) from the glove box vacuum pumps. The concentration of tritium in this oil has been estimated to be up to 50 Ci/L.

(2) 20L/year electrolyzer fluid (25% KOH) containing 0.5-1.0 Ci/L tritium.

(3) Non processable metal components (1.7m^3/year).

Part III (a) of this report (85-279-K) addressed the performance of containerized and encapsulated tritiated aqueous waste forms.

This report considers three specific questions:

Part III (b) How can tritiated oil and electrolyzer fluid be immobilized to avoid dispersion?

Part III (c) What are the characteristics (waste loading, leachability) of the resulting immobilized waste forms?

Part III (d) What conditioning requirements must be implemented to ensure that tritium losses from non-processable solid waste are less than 10^{-3}% per day?

2.0 RESULTS

2.1 Tritiated Oil

2.1.1 Oil Solidification

Previous work/6/ on radioactive oil solidification methods suggested using a technique in which the oil is mixed with a surfactant to produce an oil in water emulsion. This emulsion is subsequently mixed with Portland cement and allowed to cure to a solid product. This technique works well with lubricating, hydraulic and vacuum pump oils. Various formulations were tested using Teresso 32, a hydraulic oil, with respect to waste loading and compressive strength and two were selected for determining leaching performance. The formulations A3 and A6 and the procedure for making the solid specimens are given in Table 1 and Appendix 1 respectively.

TABLE 1

Solidification of Tritiated Oil

Formulation	A3	A6
Oil (mL)	50	125
Emulsifier (mL)	5	12.5
Water (mL)	50	50
Cement (g)	150	50
Waste Loading (%)	24	43
Compressive strength (MPa)	10.9	1.9

From the point of view of waste loading only, formulation A6 is clearly the preferred one. The rate of tritium loss from the specimens however is also a criterion for selecting the formulation although for tritiated aqueous waste it was found that the container was the primary barrier against tritium release. If this is also true for tritiated oil, then waste loading becomes the only important criterion provided it can be shown that waste loading does not increase the tritium release from the waste package. Water extendible polyester (WEP) resin was also tried as a solidification medium for oil but the waste loading was very poor (5%).

2.1.2 Speciation of Tritium in Oil

Tritium release from waste is diffusion and permeation controlled. Since these processes are mass transport phenomena, tritium losses from waste will be dependent on the chemical form of the species containing tritium. For example, when tritium gas is exposed to pump oil the beta energy from the decay of ^{3}H to ^{3}He is deposited in hydrocarbon molecules to form radicals and ions which in turn react with other molecules to form polymeric species incorporating tritium in the hydrocarbon chain.

Consequently the tritiated species in pump oil will vary from tritium gas in the case of freshly exposed oil to high molecular weight hydrocarbons as the exposure time increases. This is the reason pump oils increase in viscosity on prolonged exposure to tritium gas/7/.

The vacuum pumps at the Darlington TRF are located on the cryogenic distillation cold box and Tritium Immobilization System glove boxes. Their function is to circulate the box atmosphere through a clean up system where the tritium gas contained in the atmosphere as a result of small leaks at joints and permeation through tubing, is oxidized and absorbed on molecular sieves. The oil will "see" essentially chronically low levels of tritium gas. Under abnormal conditions such as an acute leak the oil would be exposed to high levels of tritium gas.

Two types of tritiated oil were therefore considered for the leaching program in order to cover the range of oils that are expected from the TRF. Teresso 32, a hydraulic oil, was tritiated by adding 2 g of moderator water (20 Ci/kg) to a liter of the oil. The resulting mixture, which was quite turbid, was left stirring for several months before using. The tritium content of the oil was measured to be 7.2 μCi/mL which is significantly lower than added (39 μCi/mL). This is attributed to the low water solubility of oil and in fact there were large water droplets at the bottom of the oil container. The second type of oil was obtained from AECL-CRNL. It originated from a vacuum pump on a tritium gas circulating loop. Its tritium content was 600 μCi/mL but it dropped significantly over 5 months to 440 μCi/mL presumably because of degassing. A sample of each oil was further degassed/8/ at room temperature on a vacuum rack and the volatile tritiated components identified by gas chromatography using a flow proportional counter as the detector/9/. Table 2 shows the species identified in the volatile phase of the oil samples and their concentration.

As expected, the oil exposed to tritium gas contained a much greater proportion of volatile species than the oil tritiated with moderator water. There are a number of interesting points to note from the data:

(a) In spite of the exposure of the oil to tritium gas initially, the tritium gas activity in the oil represents only 0.2% of the total volatile tritium concentration and is comparable to the concentration of tritiated hydrocarbons ethylene, propane and C_4 hydrocarbons. However the oil lost about 200 μCi/mL before this analysis was done which is very likely to have been due to the loss of tritium gas.

TABLE 2

Volatile Tritiated Species In Oil

GAS	OIL EXPOSED TO T_2 GAS		OIL EXPOSED TO DTO	
	nL/mL	^3H nCi/mL	nL/mL	^3H nCi/mL
H_2	1070	179	5	4.8*
O_2	8900	-	25600	-
N_2	48400	-	49500	-
CH_4	15.7	28.7	1.7	3.3
CO	205	-	8.2	-
CO_2	816	-	517	-
C_2H_4	13	171	1.0	3.3
C_2H_6	6.8	20.4	0.38	-
C_2H_2	0.78	17.1	0.20	5.3
C_3H_{10}	26.5	132	10.9	12.0
C_4's	68.6	102	152	6.8
C_5's	-	54.5	-	12.1
TOTAL	59600	705	75800	48

* A number of this magnitude is near the detection limit.

(b) As Table 2 shows, the total volatile tritiated species concentration up to C_5 and including tritium gas is 0.7 μCi/mL of oil. However, the quantity of tritium lost on degassing the oil was 92 μCi/mL. 5 mL of oil were degassed and if it is assumed that the bulk of the volatile tritium (21%) is due to tritiated water as HTO then the unaccounted for tritium in the volatile fraction represents approximately 0.3 μg water. It is quite possible that this amount of water adsorbed onto the glass surfaces of the vacuum rack and never made it into the gas chromatograph.

(c) The volatile tritium concentration in the oil (92 μCi/mL) is 21% of the total tritium activity. If the amount lost during transportation and handling prior to this analysis is also considered then the volatile tritium concentration is more like 42%.

In a separate experiment, the distribution of tritium between polar and non polar species present in the two types of oil was investigated. A small sample of each type of oil in iso-octane solvent was passed through a Florisil column commonly used to selectively remove highly polar contaminants from oils for the gas chromatographic analysis of PCBs. The oil exposed to tritiated water after elution through the column lost >99% of its tritium content. The oil exposed to tritium gas on the other hand lost only 66% of its tritium. It appears therefore that approximately 45% of the tritium is tied up as polar species

other than water (21%) Table 3. It is therefore to be expected that the leaching performance of the two types of oil would be quite different.

TABLE 3

Tritium Distribution in Oil[a]

Sample	Exposure	Water (mg/kg)	Tritium(uCi/mL) Before	After	Distribution
Teresso 32	DTO	118	6.4	0.01	>99% polar <1% non-polar
Vacuum pump oil.	T_2	95	435	150	34% non-polar 45% polar 21% water

(a) Report No CE86-3277-K Aug 29 1986

2.1.3 Leaching Performance of Tritiated Oil

The leach testing program looked at the following specimens:

(1) Unsolidified polyethylene containerized oil (Teresso 32) containing tritium as tritiated water. The samples were designated 01 and 02.

(2) Same as (1) except the oil(Precision B+ vacuum pump oil) exposed to tritium gas was used. These samples were designated as 03 and 04.

(3) Cement solidified tritiated oil with A3 and A6 formulations. The oil (Teresso 32) contained tritium as tritiated water. These samples were designated as A31, A32, A61 and A62.

(4) Same as (3) except the A3 formulation was containerized in a high density polyethylene (HDPE) container with a wall thickness of 0.1 cm. All specimens for leach testing were made up in duplicate.

Specimens 01,02,03 and 04 were sealed inside 0.1 cm thick 30 mL HDPE containers and leached in 900 mL distilled water under static conditions for 315 days. The data is shown in Table A.2.1 and shown graphically in Figure 1.

The behaviour of the two sets of specimens is quite different. The oil exposed initially to tritiated water lost 70% of its tritium within 80 days. In contrast, the oil exposed to tritium gas released 5% of its tritium in the first 30 days and thereafter the tritium release rate was slow ($4x10^{-3}$ %per day). In the work on tritiated aqueous waste/4/ it was shown that the permeability of water and hence tritium through polyethylene was increased when WEP resin was used as the immobilization medium. The components of the WEP resin increased the tritium release rate by a factor of 30. In the presence of oil containing tritiated water the tritium release rate was increased by a factor of >1000 (Table 4). The increase was only a factor of 10 in the case of the vacuum pump oil exposed to tritium gas. Results from qualification testing of materials used for the manufacture of polyethylene based high integrity containers in the US indicate/10/ that HDPE absorbs between 1-5% oil in the 25° C-50° C temperature range. This would have the effect of reducing the effective container thickness and hence the water permeability across the container walls.

Even though the initial tritium content of the two types of oil was adjusted to be similar to avoid possible concentration effects, the cumulative fractional release rate of tritium was more than two orders of magnitude greater from specimens in which the tritium was initially present as tritiated water (Table 4). If the cumulative fractional release rate of tritium is expressed in terms of the total tritiated water in the sample rather than the total tritium, then, the CFR rate of tritiated water from both sets of specimens should be identical, provided that the two types of oil affect polyethylene to the same degree and that the tritium release rate is not dependent on concentration. However, based on our earlier conclusion that 21% of the total tritium in specimens 03 and 04 is present as tritiated water, the cumulative fractional release rates from specimens 01 and 02 ($4.9x10^{-3}$ cm/day) is a factor of 40 greater than that from specimens 03 and 04 ($1.1x10^{-4}$ cm/day). This means that, either the above assumptions are invalid or the leaching performance of specimens 03 and 04 cannot be explained solely on the basis of tritiated water permeation through high density polyethylene. Data from reference 10 indicates a large variability in behaviour of organic materials towards HDPE, and recent work on modelling the tritium releases from water extendible polyester resin/11/ concluded that the diffusivity of tritiated water was concentration dependent. In view of this it would appear therefore that our assumptions may be suspect and that the tritium releases may in fact be dominated by tritiated water permeation through HDPE, although this needs to be confirmed by experiment.

TABLE 4

Tritium Release Rates from Containerized Tritiated Oils

SAMPLE	DESCRIPTION	CUMULATIVE FRACTIONAL RELEASE RATE (cm/day) Tritiated Water	Total Tritium
W1 W2	Tritiated water in HDPE container.	1.5×10^{-6}	-
O1 O2	Oil exposed to DTO in HDPE container.	4.9×10^{-3}	-
O3 O4	Oil exposed to T_2 gas in HDPE cont.	4.9×10^{-3} (a) 1.1×10^{-4} (b)	2.0×10^{-5} (b)
CA31 CA32	Oil exposed to DTO, cement solidified & contained in HDPE	1.8×10^{-5}	-

(a) First 30 days
(b) After 80 days

Regardless of the mechanism of tritium release it is clear that the container does not afford the same degree of retention in the presence of oil as it does when oil is absent. In the case of tritiated water,/4/ solidification was necessary only to avoid dispersion. With tritiated oil it appears that solidification is required not only for this reason but also to keep oil away from the container walls so that it can function as effectively as in the case of tritiated water alone.

To confirm this, tritiated oil was solidified using the two formulations A3 and A6. One set of A3 specimens containing duplicate samples were sealed in 0.1 cm thick HDPE containers and allowed to cure for 28 days. The second and third sets of duplicate samples consisted of solidified tritiated oil with A3 and A6 formulation but with the containers in which the specimens were made, removed after the 28 day curing period. Table A.2.2 and Figure 2 show the leaching performance of these specimens. Regardless of oil loading the release of tritium is rapid and essentially 90% of the original activity is lost in 80 days from the non containerized cement samples. The loss of tritium is accompanied by an almost complete loss of oil from the specimens over the leaching period as evidenced by a layer (2 mm) of oil on top of the leachant. The A3 waste forms were still very hard but the A6 ones, which had a higher waste loading, had become very soft and crumbly. In spite of an almost complete loss of oil from the specimens, they had increased in weight due to water absorption. It is possible that since oil (density 0.88 g/mL) is only physically encapsulated in the cement, bouyancy forces

acting on the oil in the submerged waste would cause the oil to be forced out of the cement, and water to take its place. In contrast, the loss of tritium from the solidified and containerized specimens CA31 and CA32 (Figure 3) was 1.8×10^{-5} cm/day (3.3×10^{-3} %/day). This is only a factor of three greater than the target value and should easily be reducible by increasing the container thickness to 0.25 cm.

This direct solidification route, however, could have a serious disadvantage when applied to oil exposed to tritium gas. Two situations need to be considered. Oil, freshly exposed to tritium gas,will contain a large fraction of volatile tritium and any aggressive handling such as the high speed mixing required for the emulsification step just prior to cement mixing could cause some of the tritium to be degassed, severely reducing the benefits of waste conditioning. In the second situation, oil which has been chronically exposed to tritium gas such as the one studied in this work in which the tritium has been incorporated into the hydrocarbon structure of the oil, its additives and radiolytic degradation products, will not be affected significantly by emulsification. Therefore, to cover both situations, other physical absorption processes which avoided high speed mixing were investigated. Sorbent C (expanded perlite and fibrous wood material) and Dow imbiber beads (cross linked vinyl benzene polymer) were investigated as absorbents for tritiated oils. Both types of materials are commonly used for cleaning up oil spills. The leaching of free oil in a 0.1 cm thick polyethylene container was repeated and the results together with those obtained for the absorbents are summarized in Table 5.

Clearly, imbiber beads do not reduce the tritium release rate. This is probably because the rate of absorption of the oil at ambient temperatures by imbiber beads is slow (2-3 days) during which time a significant amount of oil is absorbed by the container. Sorbent C reduces the release rate by a factor of four. At the oil/absorbent ratios investigated the CFR rate was independent of oil loading but it is still two orders of magnitude higher than from cement encapsulation. Based on our previous work on tritiated aqueous waste it was found that in going from a 0.1 cm thick container to a 1 cm one the CFR rate was reduced by a factor of 10. For oils containing significant amounts of tritiated water even this thickness will result in a release rate which is an order of magnitude higher than the target of 10-3% per day. Under these conditions several options are possible for tritiated oils containing a significant quantity of tritiated water:

(1) Solidify the oil in cement taking precautions to recover the tritium lost due to degassing.

(2) Increase further the HDPE container wall thickness,

(3) Use more than one container as the primary barrier,

(4) Investigate the use of oil resistant coatings for lining the HDPE container internals.

(5) Reduce, as far as possible, the tritiated water concentration by vacuum distillation. This will transfer the tritiated water in oil into a more manageable aqueous stream.

Table 5

Tritium Release Rate From Absorbed/Containerized Oil

SAMPLE DESCRIPTION	CUMULATIVE FRACTIONAL RELEASE RATE % per day	cm/day
Tritiated Water/Oil in 0.1cm HDPE container	1.0-1.5	$4.9\text{-}7.8\times10^{-3}$
Oil[a]:Sorbent C(1.5:1w/w) in 0.1cm HDPE container		
Oil:Sorbent C(3:1)	0.1	5.6×10^{-4}
Oil:Sorbent C(6:1)		
Oil:Imbiber Beads(4:1w/w) in 0.1cm HDPE container.	1.1	5.8×10^{-3}
Oil:Imbiber Beads(6:1w/w)	1.4	7.4×10^{-3}

(a) Tritiated water was the major contaminant in the oil.

Since tritium gas permeates through HDPE more slowly than tritiated water, oils containing a significant portion of tritium gas and tritiated hydrocarbons (>80%) contained in a 0.25 cm HDPE container and absorbed onto a material such as Sorbent C should easily meet the daily release target of 10-3%.

2.2 Electrolyzer Fluid

Electrolyzer fluid is 25% KOD solution used in a small electrolysis cell in the TRF to provide deuterium gas as make up to the catalytic exchange units where the deuterium exchanges with tritiated heavy water to form DT gas. The tritium contamination of this fluid comes about if tritiated heavy water

is used as feed to the electrolysis cell. It has been estimated/1/ that this waste stream will be generated at a rate of 22kg/year with a tritium concentration of 0.5-1.0 Ci/kg. A sample of this waste stream was made by mixing a small quantity of moderator water (20Ci/kg) with a 25% KOH solution.

2.2.1 Electrolyzer Fluid Immobilization

(A) Absorption

The absorption capacity of three readily available absorption media for 25% KOH solution was tested. The results are summarized in Table 6.

Table 6

Absorption Capacity of Various Sorbents for 25% KOH Solution

	ABSORBENTS		
	Vermiculite	Sawdust	Sorbent C
Volume of Absorbent(mL)	15	15	15
Mass of Absorbent(g)	1.3	2.2	0.8
Volume of KOH solution(mL)	4.8	10.3	2.9
Density of KOH solution(g/mL)	1.2	1.2	1.2
Capacity by Volume	0.3	0.7	0.2
Capacity by Weight	4.5	5.6	4.5

Of the three absorbents, sawdust by virtue of its higher capacity is the preferred one.

(B) Solidification

A 25% solution of KOH was added slowly to WEP resin to form a 50/50 by weight emulsion. The emulsion broke before all the KOH was added. This technique was used successfully to solidify a 10% solution using 1% by resin volume of methyl ethyl ketone peroxide catalyst but the final product was rubbery. Since it is undesirable to dilute the waste stream just to make it compatible with WEP, this approach was not pursued further. Instead, a cement based formulation that could incorporate this waste without the need to dilute was investigated. Information from the literature/12/ on cements indicates that the presence of alkalis K_2O and Na_2O in cement have two undesirable side effects which are important in regard to nuclear waste solidification. Firstly, the setting time of the cement is accelerated which makes the workability of the mix difficult due to clumping. Secondly, the alkali reacts with some types of silicates found in cement to produce reaction products which occupy a greater volume than the reactants. This reaction unfortunately occurs more slowly than the rate at which cement hardens and consequently the expansive forces can cause the cement to spall and crack. This

destructive effect can be offset by incorporating into the cement a finely divided siliceous material such as silica fume which will react with the alkalis before the cement hardens.

As Table 7 below shows, the formulation containing silica fume gave the best product and also the highest waste loading without the need to dilute the waste stream. This formulation was subsequently used to make tritiated specimens for leach testing.

TABLE 7

Formulations for the Cement Solidification of 25% KOH Solution

25% KOH (mL)	250	100	100	100
PC 30 cement (g)	150	300	-	95
Silica fume (g)	-	-	-	5
High Alumina Cement (g)	-	-	300	-
Superplasticizer (mL)	12	-	6	1.5
Product Quality (28 day cure)	Greasy solid. Deep cracks.	Surface cracks. Split in two in water.	Dense solid.	Dense solid.

2.2.2 Leach Testing

The performance of solidified specimens under leaching conditions was determined in duplicate by immersing the specimens, without the containers in which they were made in 900 mL of distilled water. The leaching data is shown in Table A.2.3 and in Figure 4. In 190 days of leaching 80% of the initial activity was lost to the leachant. Following the leaching period the specimens were found to have disintegrated. Clearly, as with other aqueous tritiated waste, containerization will be necessary for this waste stream.

2.3 Medium/High Level Tritiated Solid Waste

Non processable discarded parts that have been exposed to tritiated heavy water or deuterium gas are classified as medium level waste if the activity falls in the range of 200 mCi/m^3 to 100 Ci/m^3. Approximately 0.4 m^3 of this type of waste is estimated to be generated per year of operation of the TRF. Those parts that have been exposed to tritium gas are classified as high level tritiated waste since it is anticipated that these components will have tritium concentrations >100 Ci/m^3. The

quantity of this type of waste is estimated to be 1.3 m^3/year. Samples of solid metallic tritiated waste were obtained from AECL-CRNL. The components consisted of several small lengths of copper and stainless steel tubing as well as some high pressure stainless steel valves and Swagelok fittings. Since tritium release from solid specimens is diffusion controlled it was necessary to determine the tritium content of the specimens in order to rationalize the leaching data. This was accomplished by high temperature oxidation of the tritium in the metal. The equipment shown schematically in Figure 5 consists of a heated quartz tube connected to a series of bubblers containing water. The sample is placed inside the tube which is heated to ~800° C inside a tube furnace. Downstream of the sample but still in the heated zone of the quartz tube is a coil of copper previously oxidized to provide a catalytic surface on which the oxidation of tritium can occur. The empty tube was heated in a stream of moist air for 2 h and the downstream bubblers analyzed for tritium. This established the tritium background. This procedure was repeated for each new sample analyzed to minimize cross contamination. The metal specimen was then introduced into the quartz tube and heated in a stream of moist air for 2 h.

A slight variation of this process was used to determine the distribution of tritium in the metal oxide and the bulk metal. The sample was placed inside a flask upstream of the heated tube. Descaling solution (conc. HCl for copper and conc. HNO_3 for stainless steel) was then added to the flask containing the specimen. The vapor above the solution was drawn through the heated tube to ensure any tritium gas generated as a result of base metal corrosion is oxidized and absorbed in the bubblers, and hence accounted for in the determination of the total tritium activity of the specimens. After descaling, the sample was removed and the system flushed overnight to remove any absorbed tritium from the internal surfaces of the equipment. The descaled sample was then placed in the quartz tube and heated for 2 h in a stream of moist air. The tritium content of the descaling solution and the bubblers was subsequently measured to obtain the relative distribution of tritium in the metal oxide and the bulk metal.

The leaching data for two copper and two stainless steel specimens which had been immersed in 50 mL of distilled water are given in Table A.2.4 and Figure 6. Following the leaching period, the tritium content remaining in the specimens was determined and added to the amount lost during leaching to determine the total tritium in the specimens. For copper, 25% of the total tritium content of the specimen is rapidly released to the leachant. The subsequent release rate is essentially zero, certainly well within the 10^{-3}% per day target. For stainless steel, there is a similar rapid release of tritium but it then decreases to a steady release of 0.1% per day (7.7×10^{-5} cm/day). There are three sources of tritium associated with the copper or steel samples:

(a) Tritium gas dissolved in the bulk metal.
(b) Tritiated water adsorbed onto the metal and oxide surface.
(c) Tritiated metal oxide.

During leaching one would expect to measure the tritium associated with (b) and (c) more quickly than from (a). This is because the diffusion of tritium from the bulk metal and subsequent dissolution in the leachant is expected to be slower than the corresponding diffusion of leachant into the oxide film where isotopic exchange with adsorbed water or hydrated oxide takes place. Chemically descaling the specimens and measuring the tritium content of the descaling solutions should give a measure of the amount of tritium either adsorbed or chemically bound to the metal oxide. This assumes that there is insignificant corrosion of the base metal by the descaling solutions. Table 8 summarizes the results of descaling and the determination of the relative distribution of surface and bulk tritium.

TABLE 8

SAMPLE	Wt (g)	SCALE (μm)	SURFACE TRITIUM (μCi)	BULK TRITIUM (μCi)	TOTAL (μCi)
	1.56	-	8.9	21.5	30.4
	1.44	-	-	-	32.9
COPPER	1.47	-	10.8	25.1	35.9
	1.57	-	-	-	37.8
	1.54	-	9.1	22.4	31.5
	3.79	-	6.6	5.8	12.4
	4.41	-	-	-	16.0
STEEL	1.12	0.2	48.5(a)	16.2	64.7
	1.81	0.1	69.8(a)	64.9	134.7
	1.39	0.03	58.8(a)	14.3	73.1

(a) This number includes the tritium released during a 155 day leaching period.

The copper specimens appear to have a fairly uniform tritium specific activity of approximately 22 μCi/g. In contrast, the specific activity of tritium in stainless steel specimens is highly variable (2 μCi/g-82 μCi/g). This observation is difficult to rationalize without a knowledge of the length of time the components were exposed to tritium and from what part of the loop they were removed. For copper, the quantity of tritium lost during leaching (25%) is in excellent agreement with the amount measured as a result of descaling (30%). The tritium removed during descaling stainless steel and leaching varies from 52%-80% of the total which is surprising in view of the thin oxide film (<1 μm) expected to form on stainless steel. The attack of the base metal during descaling is negligible since the

bubblers downstream of the descaling flask consistently show <2% of the amount of tritium measured in the descaling flask.

The quantity of tritium in the bulk metal is 70% for copper and 20%-50% for stainless steel. The diffusion coefficient of hydrogen in copper and stainless steel at 20°C is 6×10^{-9} cm^2/s and 6×10^{-13} cm^2/s respectively. However, the room temperature solubility of hydrogen in copper is 5 to 6 orders of magnitude lower than in stainless steel. Hence the permeation flux out of the metals which is the product of diffusion and solubility is 2 orders of magnitude lower for copper than for stainless steel. It is also possible that copper oxide is a more effective barrier against tritium loss from the bulk metal than the oxide on stainless steel.

In view of the fact that the release of tritium from metallic components is $>10^{-3}$% per day, the effect of containerization alone was compared with WEP resin encapsulation and containerization of the resulting composite in HDPE. Earlier work/3/ had shown WEP resin to be the best of the encapsulating agents tested which included Portland cement. The reason for this was not determined but is probably due to the much larger quantity of free water in WEP which is available to dilute the tritium diffusing out of the waste. Table A.2.5 and Figures 7 and 8 summarize the data for stainless steel. Where the specimens are just containerized, the tritium release rate is only a factor of <2 lower than for specimens which had been immersed in the leachant without containers. However, the release rate is still in excess of the target value. This is a surprising result since the container was previously shown/4/ to reduce the daily tritium release rate from aqueous waste by a factor of 10C. Under the conditions of this experiment the containers with the metallic specimens were immersed in the leachant by weighting them down using containers with lead shot inside. It is possible therefore that under these circumstances the tritiated air inside the specimen containers would be forced out by the hydrostatic pressure acting on the submerged container. This experiment does not represent extended storage or waste disposal conditions and therefore the results are not considered reliable. When the specimens are encapsulated and containerized the release rate drops to approximately 10^{-4}% per day well within requirements. After the leaching period the WEP encapsulated specimens were analysed for tritium content and found to have lost a considerable fraction of the original tritium. This tritium however does not find its way into the leachant presumably because it is diluted as it diffuses through the WEP matrix which is 50% water. Cement or moist vermiculite would very likely behave similarly.

3.0 SUMMARY

(1) The tritium release from non immobilized tritiated oil contained in HDPE is dependent on the species carrying tritium and exceeds 10^{-3}% per day if >5% of the total tritium is tritiated water. The data from experiments on oil received from CRNL indicate that the permeation rate of tritiated hydrocarbons through HDPE is slow compared to tritiated water. This statement, however, assumes that the two types of oil used in this work affect polyethylene to a similar degree and should be confirmed experimentally.

(2) The presence of oil increases the permeability of tritium through HDPE. This increase of a factor of 10-1000 is attributed to absorption of the oil into the polyethylene matrix which results in a reduction of the effective container thickness. Immobilizing the tritiated oil is therefore required not only to avoid dispersion of the contents should the container be breached but also to minimize the absorption of the oil into HDPE.

(3) Of the immobilizing agents investigated, cement encapsulation was found to be the most effective compared to absorption into imbiber beads or Sorbent C cellulose fiber, presumably by virtue of the dilution of the tritiated water in the oil by the cement hydration water and subsequent incorporation of this water into the cement matrix. Cement solidification of tritiated oil in a 0.25 cm thick HDPE container is expected to give a solid product which under leaching conditions releases tritium at a rate equal to or less than 10^{-3}% per day. Cement encapsulation, however, requires high speed mixing which could liberate tritium gas and other volatile tritiated species during emulsification of the oil. This should not be a serious drawback since all tritium waste handling operations will likely be carried out in contained atmospheres.

(4) The use of absorbents like Sorbent C is tied to the tritiated water content of the oil. It requires that:

   (a) the quantity of tritiated water in the oil be reduced to <20% and
   (b) the container thickness be increased to 0.25 cm or
   (c) more than one container be used as the primary barrier or
   (d) the polyethylene container be lined with an oil resistant coating.

(5) Decontaminating tritiated oils containing significant amounts of tritiated water by a technique such as vacuum dehydration prior to waste packaging would be an attractive alternative since it would simplify tritiated waste oil processing. However, the production rate of tritiated water in oil by

oxidation of dissolved tritium and tritiated hydrocarbons during storage needs to be determined to establish the benefits of decontamination.

(6) Oil produced during operation of the Darlington TRF will need to be characterized with respect to the relative concentration of tritiated water and other tritiated species before waste packaging requirements can be finalized.

(7) Electrolyzer fluid (25% KOD) can be solidified using a mixture of Portland cement and silica fume in a ratio of 95:5. The leaching performance of this waste form is poor. An alternative approach is to absorb the solution into sawdust with a waste loading of 70% by volume. In either case the container will function as the primary barrier against tritium loss.

(8) Tritiated metallic components contain a significant fraction of the tritium as surface contamination which can be either washed off or removed by acid cleaning the metal. Once this surface contamination is removed from copper no further conditioning is required since the subsequent tritium release rate is $<10^{-3}$% per day. For stainless steel, however, the daily release rate exceeds this value even when the component is contained in polyethylene. Encapsulating the component in WEP resin followed by containerizing it in polyethylene reduced the daily tritium release rate to 10^{-4}%. This effect is attributed to dilution of the released tritium from the stainless steel by the water contained in the WEP matrix. A similar reduction is expected to be observed if cement, or in fact moist absorbent such as vermiculite, is used as the encapsulating medium.

(9) From this and previous work on tritiated aqueous waste it is apparent that the primary focus in the conditioning of all tritiated waste is packaging. High density polyethylene has very low water permeability, good corrosion resistance and is cheap and easy to fabricate. It is therefore a good candidate as the primary tritium barrier. It suffers from the disadvantage that its water permeability is reduced when in contact with organic liquids. This is not a serious problem since this effect can be easily compensated for by increasing the container thickness. Its integrity, however, cannot be guaranteed for 150 years and therefore the prudent approach is to further package this primary container inside a secondary one whose main characteristic should be corrosion resistance under the prevailing storage or disposal conditions.

4.0 CONCLUSIONS

As also observed in the work on aqueous tritiated waste, the primary barrier against tritium loss from oils and electrolyzer fluid is a water impermeable container. The immobilizing medium for these liquids serves essentially to prevent dispersion of the container contents only. In view of this and the relatively small volumes of tritiated liquid wastes expected, the simplest immobilizing method is recommended. This method involves absorption of the liquids onto a sorbent material such as Sorbent C for oils and sawdust for electrolyzer fluid. A 1 cm thick, high-density polyethylene container with a leak-tight engineered closure seal should easily meet the tritium release target for electrolyzer fluid and for oils not containing significant quantities of tritiated water as expected from the TRF.

Tritiated metallic components will need to be packaged in moisture tight containers as soon as they are removed from the system. This is to ensure that the surface tritium contamination will not result in an occupational hazard because of isotopic exchange with atmospheric humidity. An alternative to this is to decontaminate the surfaces by acid washing and neutralizing the solutions (perhaps using electrolyzer fluid) prior to discharge as tritiated aqueous waste. Following decontamination, copper components will not require further conditioning but stainless steel ones will need to be packaged in a moisture impermeable container such as high density polyethylene.

The work on tritiated waste conditioning has assumed two performance criteria for the development of conditioning techniques. It is not known at this time whether these criteria are considered conservative or not. This work, however, has established some fundamental trends which will enable the designers to engineer suitable packages for these wastes. Even if the release criteria are made more stringent, the results of this work will allow them to be met without additional research. In any event it is recommended that the engineered package be proof tested under laboratory conditions prior to field use.

ACKNOWLEDGEMENT

Samples of tritiated oil and solid components were supplied by AECL. The author wishes to thank Dr. W.J. Holtslander for making these available. The technical assistance of Dr. R.E. Massey and Mr. J.W. McPherson is gratefully acknowledged.

Approved by:

O.A. Kupcis
Manager
Chemical Research Dept

Prepared by:

J.P. Krasznai
Engineer
Materials Chemistry
Research Section

Reviewed by:

R.W. Glass
Supervising Chemist
Materials Chemistry
Research Section

APPENDIX 1

Method for the Solidification of Oil

PROCEDURE

(1) The PC30 cement was passed through No 20 mesh sieve to ensure it was free of large clumps.

(2) Triton X114, a surfactant, was added to the water and oil subsequently added with stirring to give a milky white emulsion.

(3) Cement was added with stirring and the specimens were covered and left to cure for 28 days prior to leach testing.

Method for the Solidification of 25% KOH Solution

PROCEDURE

(1) The PC30 cement was passed through No 20 mesh screen and then mixed with silica fume. Care must be taken to avoid inhaling this very fine dust.

(2) The KOH solution was then added together with 2% by weight of cement of MK 150 Superplasticiser. The resulting mixture which was very fluid was poured into containers and sealed.

APPENDIX 2

LEACHING DATA

TABLE A.2.1

SAMPLE: O-1, O-2, O-3, O-4
SAMPLE DESCRIPTION: TRITIATED OIL UNSOLIDIFIED.SAMPLE O1&O2 IS
TERESSO 32 CONTAMINATED WITH MODERATOR WATER.SAMPLE
O3&O4 IS VACUUM PUMP OIL EXPOSED TO TRITIUM GAS.
SPECIMEN SURFACE AREA S: O1&O2 60.85cm*2, O3&O4 54.45cm*2
SPECIMEN VOLUME V: O1&O2 30.0cm*3, O3&O4 25cm*3
CONTAINER THICKNESS: 0.10cm
VOLUME OF OIL IN SPECIMEN: O1&O2 30.0cm*3, O3&O4 25cm*3
INITIAL TRITIUM ACTIVITY: O-1 201.0uCi O-3 197.5uCi(41.5uCi as tritiated water)
O-2 201.0uCi O-4 197.5uCi(41.5uCi as tritiated water)

TIME (DAYS)	CUMULATIVE RELEASE(uCi)				CUMULATIVE FRACTIONAL RELEASE					
	O-1	O-2	O-3	O-4	O-1	O-2	AVG	O-3	O-4	AVG
1	2.35	3.01	0.66	0.59	0.012	0.015	0.013	0.003 (0.016)	0.003 (0.014)	0.003 (0.015)
2	4.67	5.80	1.25	1.16	0.023	0.029	0.026	0.006 (0.030)	0.006 (0.028)	0.006 (0.029)
4	7.10	11.16	2.71	2.49	0.035	0.056	0.045	0.014 (0.065)	0.013 (0.060)	0.013 (0.063)
25	53.05	57.69	11.12	10.59	0.264	0.287	0.275	0.056 (0.268)	0.054 (0.255)	0.055 (0.262)
80	140.60	146.10	17.68	17.07	0.707	0.727	0.713	0.090 (0.426)	0.086 (0.411)	0.088 (0.419)
100	151.60	156.50	17.20	16.70	0.754	0.779	0.766	0.087 (0.414)	0.085 (0.402)	0.086 (0.408)
144	171.57	174.40	18.00	17.40	0.854	0.868	0.861	0.091 (0.434)	0.088 (0.419)	0.090 (0.427)
200	182.82	183.47	18.19	17.19	0.910	0.913	0.911	0.092 (0.438)	0.087 (0.414)	0.090 (0.426)
268	190.80	191.90	19.10	18.40	0.949	0.955	0.952	0.097 (0.460)	0.093 (0.443)	0.095 (0.452)
315			20.11	18.03				0.102 (0.485)	0.091 (0.434)	0.097 (0.460)

Note: Numbers in parenthesis are the CFR values based on the quantity of tritiated water estimated to be in the CRNL oil samples.

TABLE A.2.2.

SAMPLE:A31, A32, CA31, CA32, A61, A62
SAMPLE DESCRIPTION: CEMENT SOLIDIFIED TRITIATED OIL(A3&A6 FORMULATIONS)
WITH AND WITHOUT CONTAINER.
SAMPLE SURFACE AREA S: A31 56.3cm*2 A32 53.3cm*2 A61 53.3cm*2
A62 55.3cm*2 CA31 54.3cm*2 CA32 56.3cm*2
SPECIMEN VOLUME V: A31 32.2cm*3 A32 29.8cm*3 A61 29.8cm*3
A62 31.4cm*3 CA31 30.6cm*3 CA32 32.2cm*3
CONTAINER THICKNESS: 0.10cm
VOLUME OF OIL IN SPECIMEN: A31 8.83mL A32 8.31mL A61 12.98mL
A62 13.48mL CA31 8.63mL CA32 9.04mL
INITIAL TRITIUM ACTIVITY: A31 44.16uCi A61 64.90uCi CA31 43.16uCi
A32 41.55uCi A62 67.42uCi CA32 45.16uCi

TIME (DAYS)	CUMULATIVE RELEASE(uCi)						CUMULATIVE FRACTION RELEASED								
	A31	A32	CA31	CA32	A61	A62	A31	A32	AVG	CA31	CA32	AVG	A61	A62	AVG
1	11.15	8.91	0.00	0.00	27.54	28.52	0.25	0.21	0.23	0.0000	0.0000	0.0000	0.42	0.42	0.42
3	15.24	14.79	0.00	0.00	38.89	41.15	0.35	0.36	0.35	0.0000	0.0000	0.0000	0.60	0.61	0.60
7	19.86	16.73	0.00	0.00	45.57	46.31	0.45	0.40	0.43	0.0000	0.0000	0.0000	0.70	0.69	0.69
27	28.58	28.11	0.03	0.02	57.64	65.90	0.65	0.68	0.66	0.0007	0.0004	0.0006	0.89	0.98	0.93
77	40.86	36.46	0.09	0.08	59.55	61.13	0.93	0.88	0.90	0.0021	0.0018	0.0019	0.92	0.91	0.91
142	39.09	36.84	0.20	0.18	57.98	58.61	0.89	0.89	0.89	0.0046	0.0040	0.0043	0.89	0.87	0.88
167	41.18	36.35	0.23	0.24	58.78	62.99	0.93	0.87	0.90	0.0053	0.0053	0.0053	0.91	0.93	0.92

TABLE A.2.3

SAMPLE: KOH 1, KOH 2
SAMPLE DESCRIPTION: ELECTROLYZER SOLUTION SOLIDIFIED
WITH PORTLAND CEMENT/SILICA FUME.
SPECIMEN SURFACE AREA S: KOH 1, KOH 2, 175.60cm2
SPECIMEN VOLUME V: KOH 1, KOH 2, 107.94cm3
CONTAINER THICKNESS: 0 cm
VOLUME OF WATER IN SPECIMEN: KOH 1 83.85cm3, KOH 2 84.57cm3
INITIAL TRITIUM ACTIVITY: KOH 1 10481uCi, KOH 2 10571uCi

TIME (DAYS)	CUMULATIVE RELEASE(uCi)		CUMULATIVE FRACTIONAL RELEASE		
	KOH 1	KOH 2	KOH 1	KOH 2	AVG
1	848.70	849.50	0.08	0.08	0.08
2	1185.40	1187.10	0.11	0.11	0.11
3	1096.00	1457.80	0.10	0.14	0.12
4	1673.10	1781.70	0.16	0.17	0.16
7	2157.60	2254.30	0.21	0.21	0.21
14	2370.70	2485.20	0.23	0.24	0.23
25	3597.60	3855.50	0.34	0.36	0.35
60	5257.00	5310.00	0.50	0.50	0.50
80	5718.50	5837.70	0.55	0.55	0.55
190	8243.00	8482.00	0.79	0.80	0.79

TABLE A.2.4.

SAMPLE: Cu1, Cu2, SS1, SS2
SAMPLE DESCRIPTION: SECTIONS OF COPPER AND STAINLESS STEEL TUBING
EXPOSED TO TRITIUM GAS AT ORNL.
SPECIMEN WEIGHT: Cu1 5.94gms Cu2 5.90gms SS1 6.58gms SS2 6.66gms
SPECIMEN DIMENSIONS:5.1cm long 0.63cm(OD) 0.32cm(ID)
SPECIMEN SURFACE AREA S (AVG ID & OD): 15.2cm**2
SPECIMEN VOLUME V: 1.2cm**3
INITIAL TRITIUM ACTIVITY: Cu1:132.8uCi Cu2:118.3uCi
SS1:11.0uCi SS2:544.8uCi

TIME (DAYS)	CUMULATIVE RELEASE(uCi)				CUMULATIVE FRACTIONAL RELEASE					
	Cu1	Cu2	SS1	SS2	Cu1	Cu2	AVG(Cu1,2)	SS1	SS2	AVG(SS1,2)
1	22.99	21.90	2.40	0.00	0.17	0.19	0.18	0.22	0.00	0.11
2	22.74	21.05	1.66	128.79	0.17	0.18	0.17	0.15	0.24	0.19
7	26.40	37.70	6.30	139.80	0.20	0.32	0.26	0.57	0.26	0.26
33	33.37	30.07	3.31	178.41	0.25	0.25	0.25	0.30	0.33	0.31
58	31.28	32.27	3.53	202.36	0.24	0.27	0.25	0.32	0.37	0.35
73	30.57	28.57	3.61	208.24	0.23	0.24	0.24	0.33	0.38	0.36
115	32.54	32.12	3.88	231.85	0.25	0.27	0.26	0.35	0.43	0.39
155	32.20	31.70	4.10	272.80	0.24	0.27	0.26	0.37	0.50	0.44

TABLE A.2.5.

SAMPLE:SS9, SS10, SS11, SS12.
SAMPLE DESCRIPTION: SECTIONS OF STAINLESS STEEL TUBING
EXPOSED TO TRITIUM GAS AT CRNL.
SS9 & SS11 SEALED INSIDE A 0.1cm THICK HDPE
CONTAINER. SS10 & SS12 ENCAPSULATED IN WEP RESIN
AND SEALED INSIDE A 0.1cm THICK HDPE CONTAINER.
SAMPLE WEIGHT: SS9 1.57gms SS10 3.27gms(with ferrule)
SS11 3.05gms (with ferrule) SS12 1.96gms
SAMPLE DIMENSIONS: SS9: 1.2cm(l)×0.63cm(OD)×0.32cm(ID)
SS10: 1.4cm(l)×0.63cm(OD)×0.32cm(ID)
SS11: 1.4cm(l)×0.63cm(OD)×0.32cm(ID)
SS12: 1.6cm(l)×0.62cm(OD)×0.32cm(ID)
SAMPLE SURFACE AREA S: 3.62-4.83cm×2
INITIAL TRITIUM ACTIVITY: SS9:76.75uCi SS10:138.9uCi×
SS11:110.1uCi SS12:83.2uCi×
× These values are calculated not measured.

TIME (DAYS)	CUMULATIVE RELEASE				CUMULATIVE FRACTIONAL RELEASE					
	SS9(uCi)	SS11(uCi)	SS10(uCi)	SS12(uCi)	SS9	SS11	AVG	SS10	SS12	AVG
2	0.07	0.08	0.004	0.002	0.00090	0.00073	0.00082	0.00003	0.00003	0.00003
4	0.28	0.21	0.004	0.005	0.00361	0.00191	0.00276	0.00003	0.00006	0.00004
8	1.45	1.15	0.005	0.006	0.01893	0.01044	0.01469	0.00003	0.00007	0.00005
9	1.79	1.46	0.005	0.005	0.02332	0.01322	0.01827	0.00004	0.00005	0.00004
11	2.20	1.77	0.008	0.005	0.02870	0.01612	0.02241	0.00005	0.00006	0.00006
15	3.10	2.54	0.007	0.007	0.04043	0.02306	0.03175	0.00005	0.00008	0.00007
35	4.87	5.70	0.010	0.010	0.06345	0.05178	0.05762	0.00007	0.00012	0.00010
85	8.22	10.52	0.020	0.010	0.10710	0.09557	0.10133	0.00014	0.00012	0.00013
123	9.82	12.93	0.020	0.020	0.12795	0.11746	0.12270	0.00014	0.00024	0.00019
150	10.71	14.46	0.020	0.020	0.13954	0.13136	0.13545	0.00014	0.00024	0.00019

Figure 1

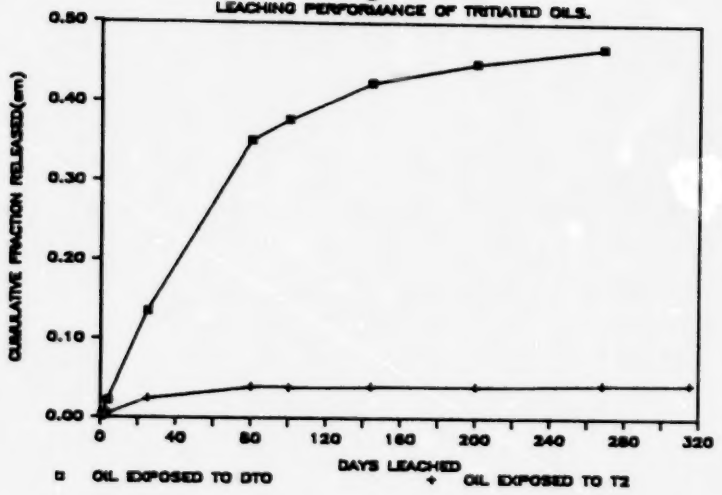


Figure 2

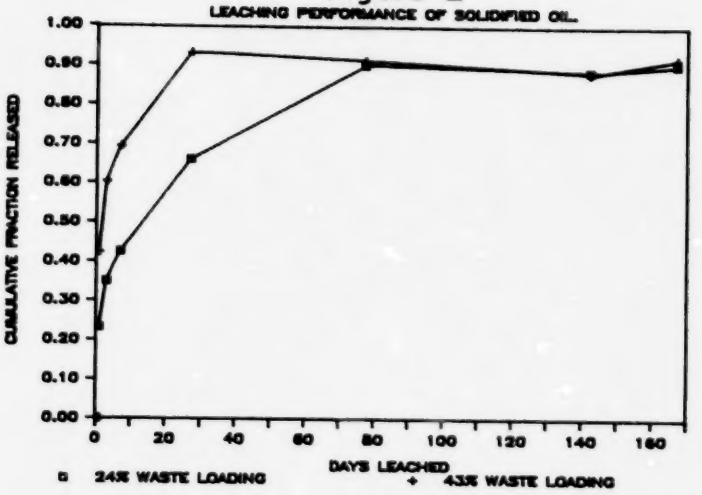


Figure 3

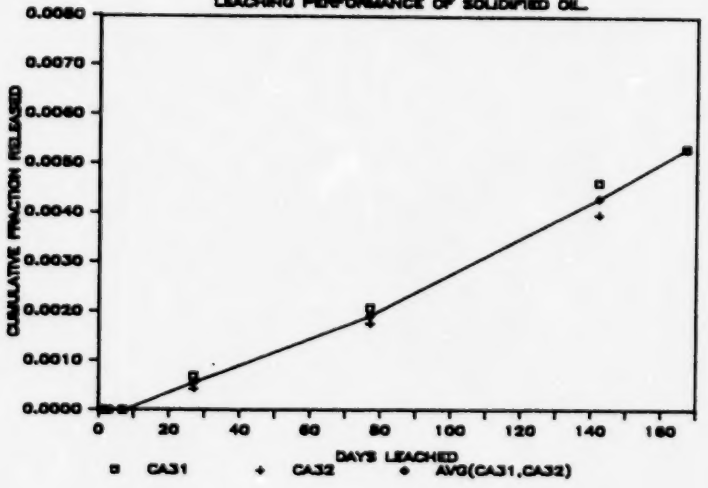
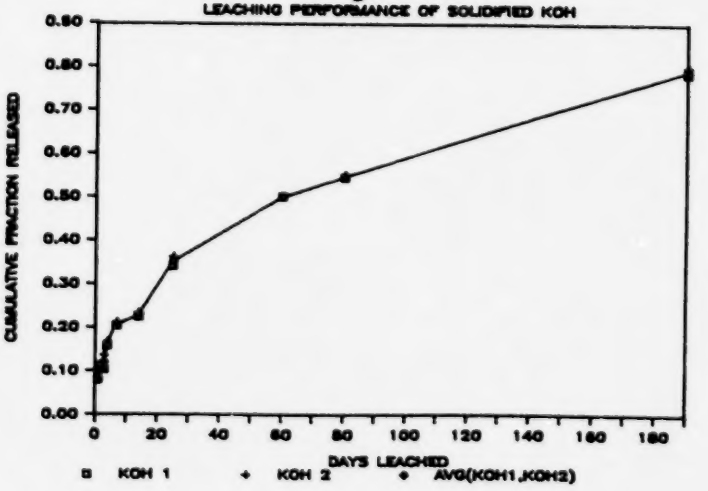


Figure 4.



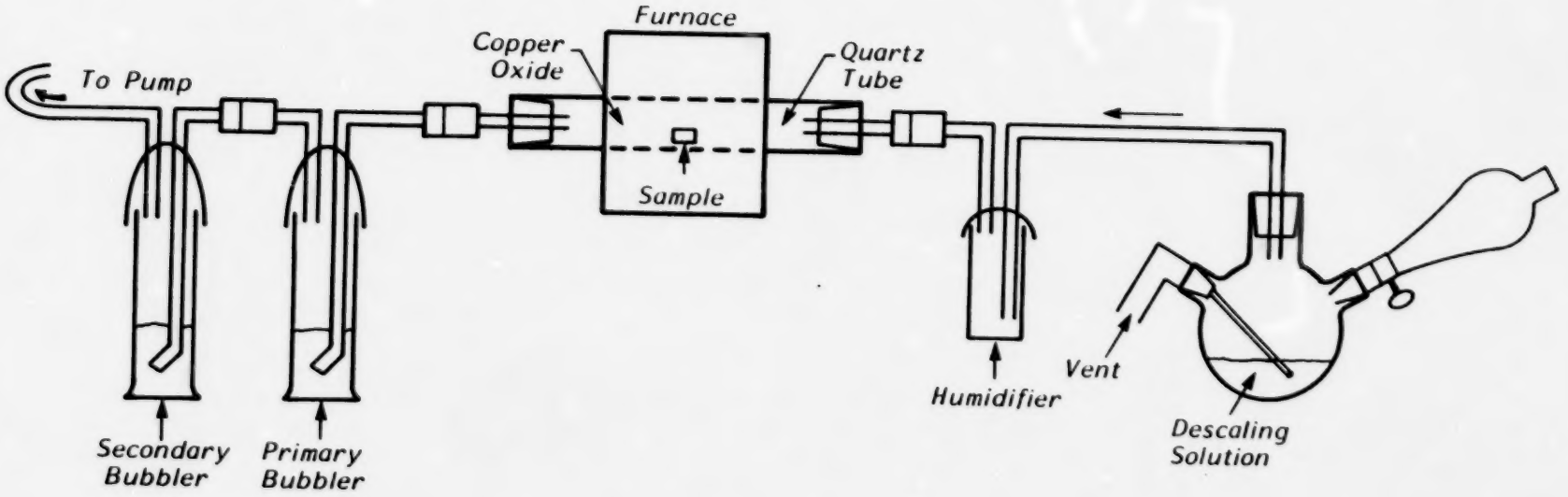


FIGURE 5
COMBUSTION TRAIN FOR DETERMINATION OF TRITIUM
IN METAL COMPONENTS

Figure 6

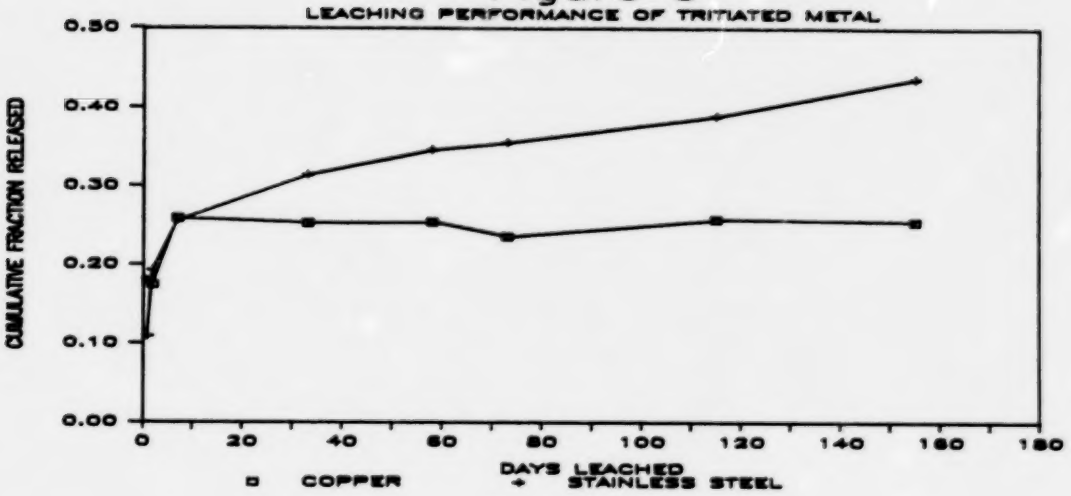


Figure 7

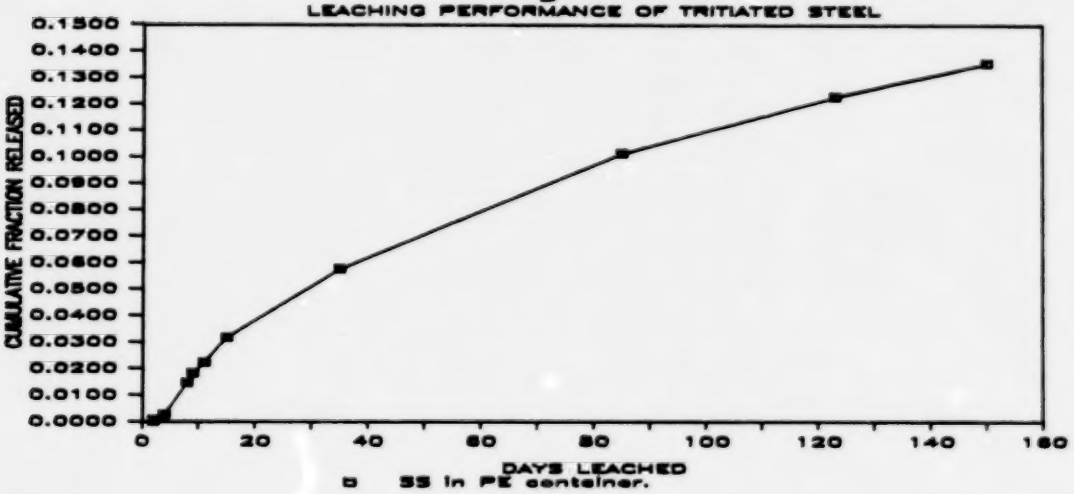
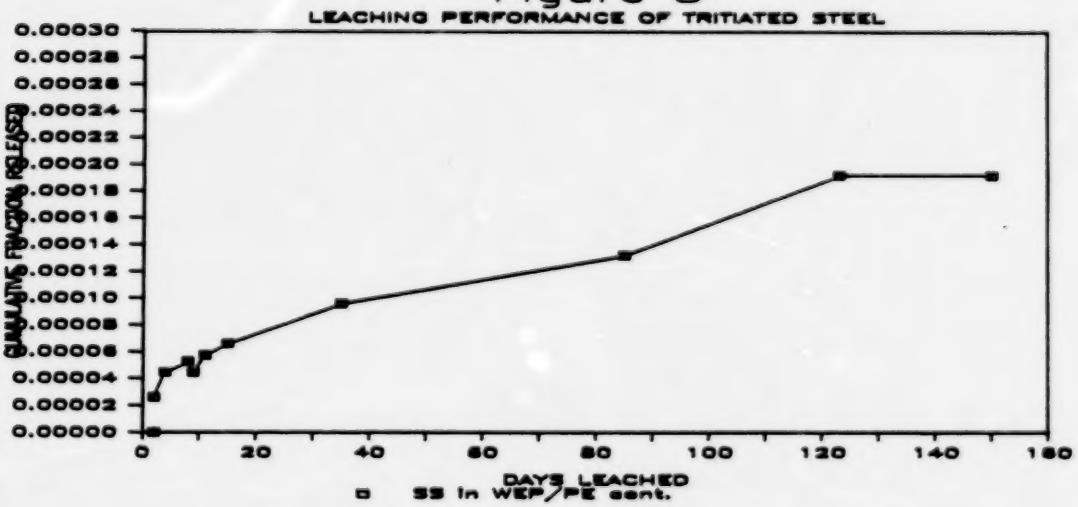


Figure 8



REFERENCES

1. Garamszeghy, M. Darlington TRF: Summary of Radioactive Waste Generation, Handling and Storage, Report No 85091, March 1985.

2. Hawthorne, S.H., "Conditioning of Tritiated Waste Part I - Tritiated Water Immobilization," Ontario Hydro Research Division Report No 82-531-K, 1982.

3. Hawthorne, S.H., "Conditioning of Tritiated Waste Part II- Solidification and Encapsulation," Ontario Hydro Research Division Report No 84-6-K, 1984.

4. Krasznai, J.P., "Conditioning of Tritiated Waste Part III(a) Performance of Containerized and Encapsulated Waste Forms," Ontario Hydro Research Division Report No 85-279-K, 1985.

5. McKay, H.A.C., "Tritium Immobilisation", European Applied Research Report-Nuclear Science and Technology Section Vol. 1, No. 3(1979), pp. 599-711.

6. Hawthorne, S.H., "Immobilization of Radioactive Waste Oil Part I - Non Active Oil Studies," Ontario Hydro Research Division Report No 83-350-H, 1983.

7. Shmayda, W.T., "Tritium Interactions with Materials," Ontario Hydro Research Division Draft Report, Sept. 1984.

8. Massey, R.E., "Transformer Gas Analysis," Ontario Hydro Research Division Report No 85-6-K, 1985.

9. Massey, R.E., "Chromatographic Separation of Hydrogen Isotopes," Ontario Hydro Research Division Report No 86-?-H to be issued.

10. Sharpe, R.A., Westinghouse Hittman Nuclear Inc. Private Communication, Aug 11, 1986.

11. Gonzalez, L.A., "Diffusion of Radionuclides in Non-metallic Solids of Different Shapes, Part II," Ontario Hydro Research Division Report No 86-55-K, July 1986.

12. Second Edition, "The Composition and Properties of Concrete," Troxell, Davis and Kelly, Page 22.

DISTRIBUTION

Dr. D. Mills	Director of Research
*Mr. H.N. Isaac	Design & Development-Gen, H11G27
*Mr. T.J. Carter	Design & Development-Gen, H11G27
Mr. J.S. Li	Design & Development-Gen, H11E27
Mr. R.E. Heathcock	Design & Development-Gen, H11G26
Dr. S.J. Naqvi	Design & Development-Gen, H11D18
Mr. L.S. Krochmalnek	Design & Development-Gen, H11F18
Mr. R. Kohout	Design & Development-Gen, H11F18
*Dr. D.P. Dautovich	CFFTP
Mr. K. Wong	CFFTP
Mr. L.P. Buckley	AECL Chalk River Nuclear Laboratory
Dr. W.J. Holtslander	AECL Chalk River Nuclear Laboratory
Prof. Dr.E. Merz	Institute for Chemical Technology Kernforschungsanlage Julich GmbH D-5170 Julich 1 Fed. Republic of Germany
Mr. G. Dicke	RMEP TTSD
*Dr. J. Brown	Metallurgical Research
Dr. W.T. Shmayda	Metallurgical Research
Dr. R.W. Glass	Chemical Research
Mr. A.S. Williamson	Chemical Research
Dr. J.P. Krasznai	Chemical Research

Public Reference Center
Editorial Section (2)
Office Copies (3)
Extra Copies (3)

*Executive Summary Only